

## Chemistry 12

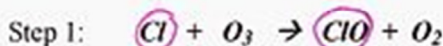
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## Worksheet 1-3 - Reaction Mechanisms

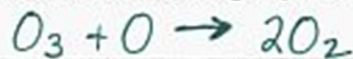
1. It is known that compounds called *chlorofluorocarbons* (C.F.C.s) (eg.  $\text{CFCl}_3$ ) will break up in the presence of ultraviolet radiation, such as found in the upper atmosphere, forming single chlorine atoms:



The Cl atoms then react with Ozone ( $\text{O}_3$ ) as outlined in the following mechanism.



- a) Write the equation for the *overall reaction*. (Using steps 1 and 2)



- b) What is the *catalyst* in this reaction?

$\text{Cl}$

- c) Identify an *intermediate* in this reaction

$\text{ClO}$

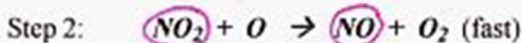
- d) Explain how a *small* amount of chlorofluorocarbons can destroy a *large* amount of ozone.

When a Cl atom destroys an  $\text{O}_3$  molecule (Step 1), it is regenerated (Step 2) so it can destroy more

- e) What breaks the bond in the  $\text{CFCl}_3$  and releases the free Cl atom?

a photon ( $h\nu$ ) of ultraviolet radiation

2. Given the following mechanism, answer the questions below:



- a) Give the equation for the *overall reaction*.



- b) What could the *catalyst* be in this mechanism?

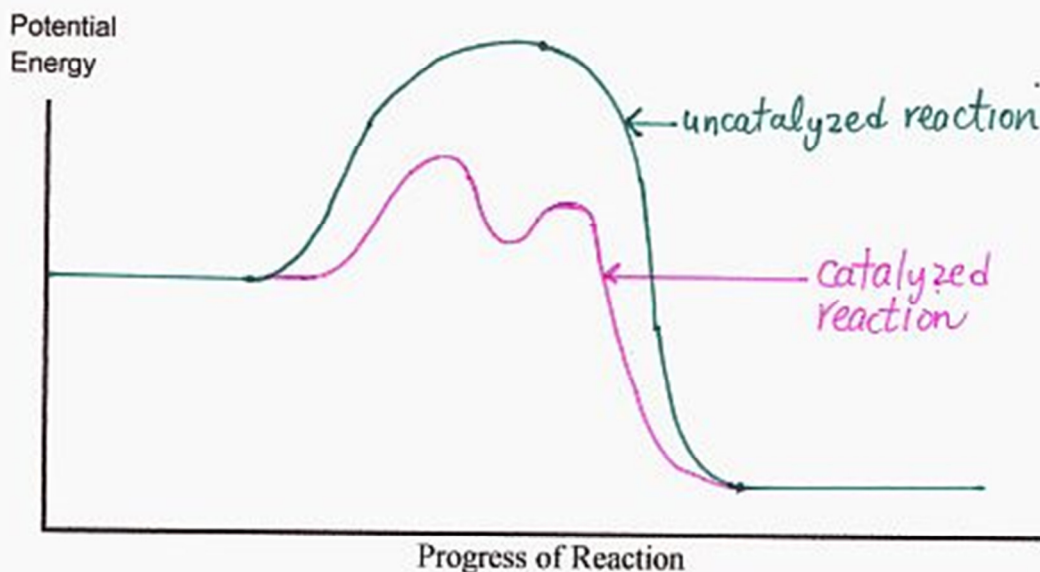
$\text{NO}$

- c) What is an *intermediate* in this mechanism?

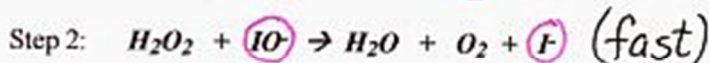
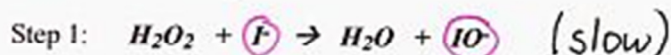
$\text{NO}_2$

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- d) Given that the **uncatalyzed** overall reaction is a *slow exothermic* reaction, draw a *potential energy graph* which shows the possible shape of the curve for the **uncatalyzed** reaction. On the same graph, show a possible curve for the **catalyzed** reaction.



3. Consider the following mechanism:



- a) Give the equation for the overall reaction.



- b) What acts as a **catalyst** in this mechanism?



- c) What acts as an **intermediate** in this mechanism?



4. What is meant by the **rate determining step** in a reaction mechanism? the

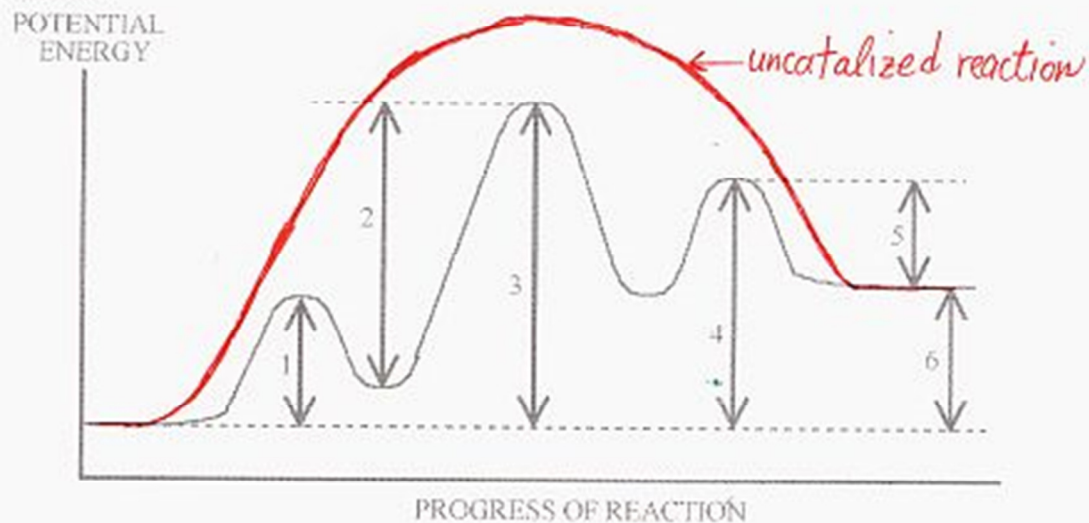
slowest step. (Step 1)

5. What is meant by a **reaction mechanism**? A sequence (or series) of elementary processes (steps) by which a rx. takes place.

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6. How are reaction mechanisms determined? research with rate studies - looking for evidence of intermediates etc.

7. Given the following *Potential Energy Diagram* for a 3 step reaction, answer the questions below it:

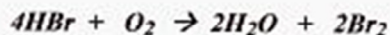


- a) Which arrow indicates the *activation energy* for the *first* step of the reverse reaction? 5
- b) Which arrow indicates the *activation energy* for the *first* step of the forward reaction? 1
- c) Which arrow indicates the *activation energy* for the *second* step of the forward reaction? 2
- d) Which arrow indicates the *enthalpy change* ( $\Delta H$ ) or "*enthalpy change*" for the overall forward reaction? 6
- e) Which arrow indicates the *enthalpy change* ( $\Delta H$ ) or "*enthalpy change*" for the overall reverse reaction? 6



**KEY**f) Which arrow indicates the *activation energy* for the **overall** forward reaction?3g) Which step would be the *rate determining step* in the *forward* reaction?step 2h) In a dashed line or another colour sketch a possible curve that would represent the route for the **uncatalyzed overall reaction**. Label this on the graph.

8. Given the reaction:



a) Would you expect this reaction to take place in a single step?

no

Why or why not?

5 particles in reactants - small probability of a simultaneous collision

b) This reaction is thought to take place by means of the following mechanism:

c) Identify the two *intermediates*HOBr & HOBrd) A catalyst is discovered which increases the rate of *Step 3*. How will this affect the rate of the *overall reaction*?no effect

Explain your answer.

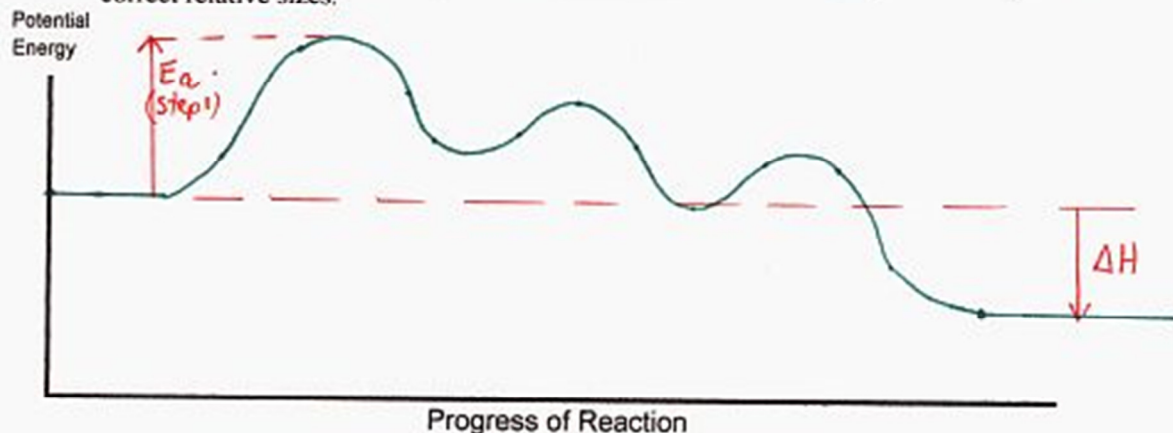
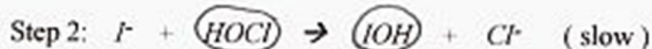
you must speed up the slowest step (RDS) in order to speed up the overall reactione) A catalyst is discovered which increases the rate of *Step 1*. How will this affect the rate of the *overall reaction*?it will increase the rate

Explain your answer.

when you speed up the slowest step (RDS), the whole process (overall rx.) speeds up.f) Which step has the greatest *activation energy*?step 1

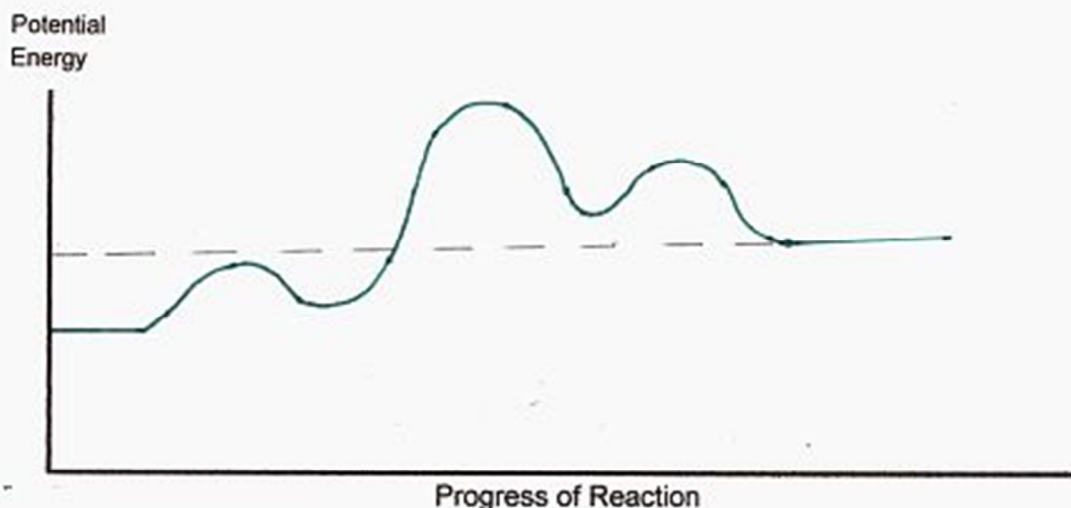
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g) How many "bumps" will the potential energy diagram for the reaction mechanism have?

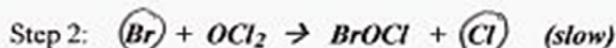
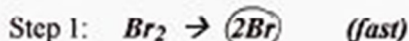
3h) Which step is called the *rate determining step* in this mechanism? step 1i) In order to have successful collisions, the colliding particles must have **both** the proper amount of *energy* and the proper collision geometryj) On the set of axes below, draw the shape of the curve you might expect for the reaction in this question. The overall reaction is exothermic! Make sure you get the "bumps" the correct relative sizes.9. The equation for an *overall* reaction is:a) The following is a proposed *mechanism* for this reaction. One of the species has been left out. **Determine what that species is and write it in the box.** Make sure the *charge* is correct if it has one!b) Which species in the mechanism above acts as a *catalyst*? H<sub>2</sub>Oc) Which three species in the mechanism above are *intermediates*? HOCl, OH<sup>-</sup>, IOHd) Step 2 is the *rate determining step*.

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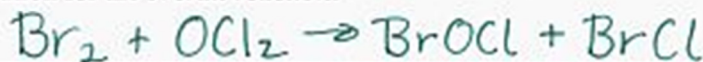
- e) On the set of axes below, draw the shape of the curve you might expect for the reaction in this question. The overall reaction is endothermic! Make sure you get the "bumps" the correct relative sizes.



10. Given the following steps for a mechanism:



- a) Write the equation for the *overall reaction*.

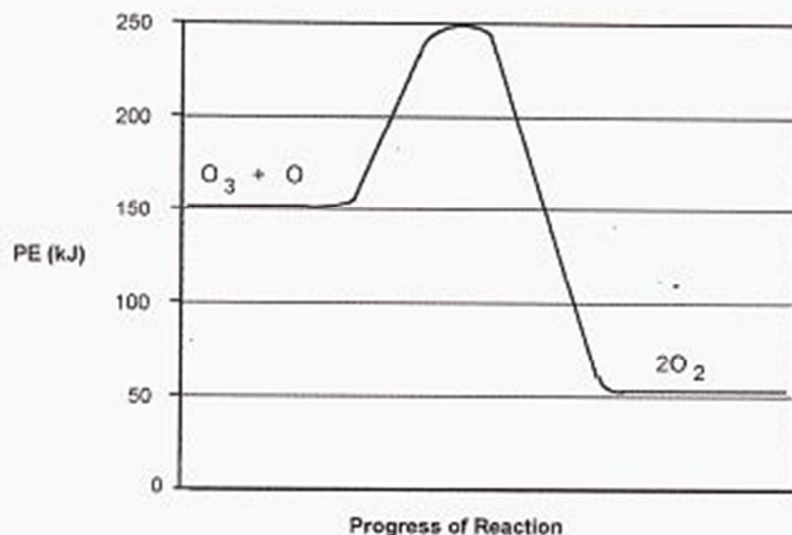


- b) A substance is added that *decreases* the activation energy for step 1. Will this speed up, slow down, or have no effect on the rate of the overall reaction? no effect  
Give a reason for your answer. Step 1 is not the RDS
- c) Is there a *catalyst* in this mechanism? no. If so, what is it? \_\_\_\_\_
- d) Is there an *intermediate* in this mechanism? yes. If so, what is it? Br & Cl
- e) Which step is the *rate determining step*? step 2

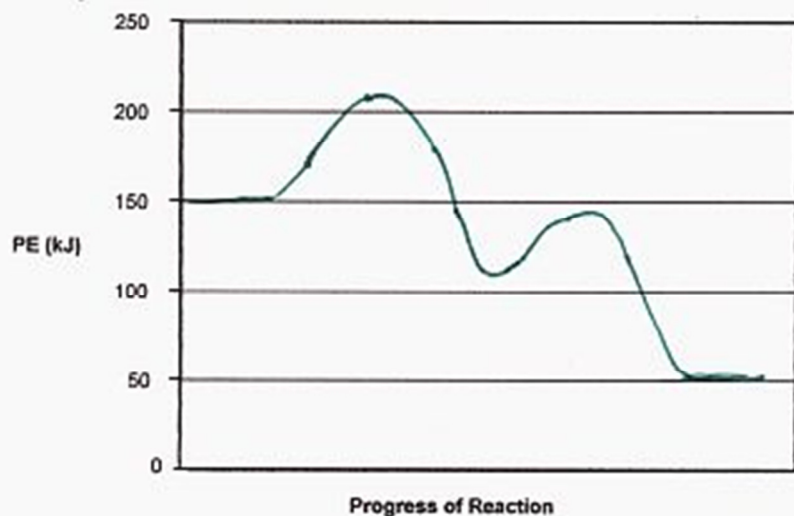
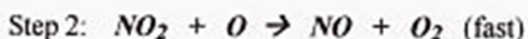


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11. The following *potential energy diagram* refers to a very slow one-step reaction of ozone ( $O_3$ ) and oxygen atoms in the upper atmosphere.



On the axis below, draw a potential energy diagram which could represent the *catalyzed mechanism* for the reaction:



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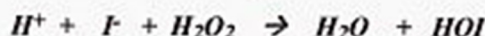
12. A certain chemical can provide a reaction with an alternate mechanism having a greater activation energy. What will happen to the rate of the reaction when this chemical is added?

no change

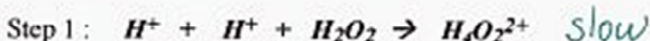
Explain your answer.

the reaction will continue to take place following the original (lower  $E_a$ ) mechanism.

13. The following overall reaction is *fast* at room temperature:



A student proposes the following two-step mechanism for the above reaction:



Would you agree or disagree with this proposed mechanism?

disagree

Explain your answer

Step 1 involves a collision of 3 particles which would be slow. Therefore the overall rx. could not be fast as is observed.

14. Consider the following reaction:



a) The first step in each of two proposed reaction mechanisms for the above reaction is listed below. If each proposed reaction mechanism consists of only two steps, **determine the second step for each mechanism.**

Proposed Mechanism One:Proposed Mechanism Two:

b) Experimental data show that the rate of the reaction is *not* affected by a change in the

[CO]. Which of these two mechanisms would be consistent with these data? 1

Explain your answer. In mech 2, CO is a reactant in the RDS

Increasing [CO] would speed up step 2 and the overall rx.

In mech. 1, CO is not a reactant in the RDS, so no effect